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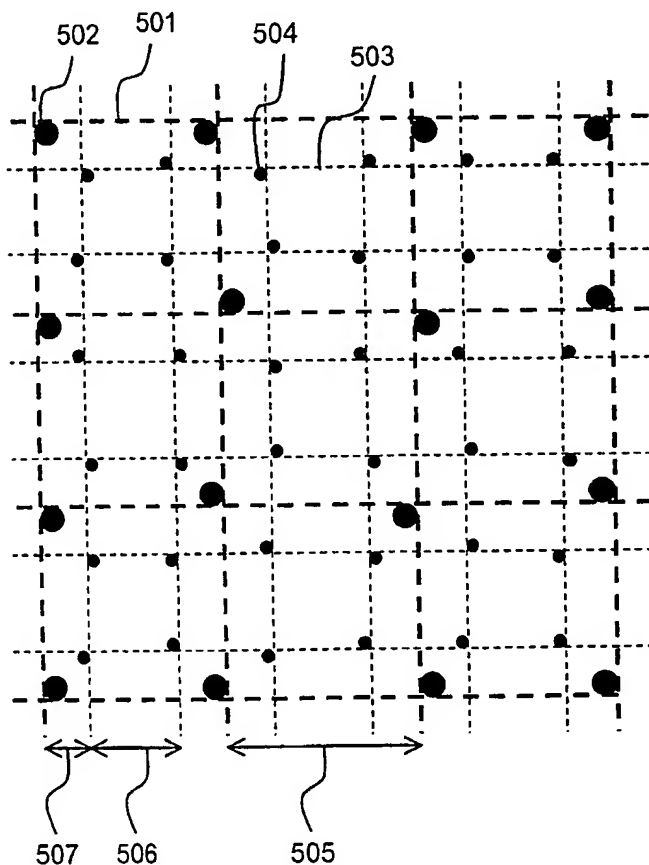
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(54) Title: INFORMATION-RELATED DEVICES AND METHODS

(57) Abstract: A product has a surface provided with a first coding pattern and a second coding pattern. The coding patterns comprise symbols each of which represents at least two different values. Each symbol in the first coding pattern comprises one raster point and at least one marking, the raster point being included in a first raster which extends over the surface. Each symbol in the second coding pattern also comprises one raster point and at least one marking, the raster point being included in a second raster. This second raster is displaced in relation to the first raster and has a different spatial scale than the first raster. Each symbol in the first and the second pattern has a value which, for example, can be indicated by the location of the marking belonging to the respective symbol in relation to a raster point in the first and, respectively, second raster.

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INFORMATION-RELATED DEVICES AND METHODS

TECHNICAL FIELD

The present invention relates to devices and methods
related to surfaces which are provided with an informa-
tion-coding pattern.

BACKGROUND

In many situations it is desirable to be able to
determine an absolute position on a surface. One example
is the recording and digitization of documents such as
drawings, maps etc. Another one is if it is desired to
create an electronic version of handwritten information.

In these and other situations, where position-deter-
mination is carried out, it is often desirable to facili-
tate for, for example, a computer program in cooperation
with an input device to carry out calculations which are
related to the position-determination and, in particular,
to provide the possibility of being able to read and pro-
cess both position information and other information
which, for example, can be related to the absolute posi-
tions read and determined.

US 5,852,434 describes a device for determining an
absolute position. The device comprises a writing surface
which is provided with a position-coding pattern by means
of which X-Y coordinates can be determined, a detector
which can detect the position-coding pattern and a pro-
cessor which can determine the position of the detector
in relation to the writing surface on the basis of the
detected position-coding pattern. The device makes it

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possible for a user to input handwritten and hand-drawn
information into a computer at the same time as the
information is written/drawn on the writing surface.

One shortcoming of the prior art summarized above is that
5   it does not facilitate for, for example, a computer
program in cooperation with an input device to carry out
calculations which are related to position determination
since only position information is handled.

A further shortcoming of the known pattern is that it is
10   made up of complex symbols, the information content of
which relates to the positions themselves. The smaller
the symbols are the more difficult it is to produce the
patterned writing surface and the greater the risk of
incorrect position determinations, but the larger the
15   symbols are the worse is the position resolution.

It is thus a problem to enable a large amount of
information to be read and processed from surfaces pro-
vided with coding patterns.

SUMMARY OF THE INVENTION

20   It is an object of the present invention to remedy said
problems. This is achieved by a product according
to claim 1, a method and a computer program according to
claims 17 and 31, respectively, and a method, a computer
program and a device according to claims 32, 37 and 38,
25   respectively.

A first aspect of the invention is a product which has a
surface provided with a first coding pattern and a second
coding pattern. The coding patterns comprise symbols each
of which represents at least two different values. Each
30   symbol in the first coding pattern comprises one raster
point and at least one marking, the raster point being

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included in a first raster which extends over the
surface. Each symbol in the second coding pattern also
comprises one raster point and at least one marking, the
raster point being included in a second raster. This

5   second raster is displaced in relation to the first
raster and also has a different spatial scale than the
first raster. In a preferred embodiment, each symbol in
the first and the second pattern has a value which is
indicated by the location of the marking belonging to the

10   respective symbol in relation to a raster point in the
first and respectively second raster. Another preferred
way of indicating the values of the symbols comprises
varying the size of the markings as is described in
Applicant's International Patent Application WO 00/73983.

15   Moreover reference is also made to PCT/SE00/01895 and WO
01/16691, the contents of which are included by
reference.

By determining the displacement between the first and the
second raster, the distance between the raster points in

20   the first raster and the distance between the raster
points in the second raster so that they do not have a
common denominator greater than one, an advantage is
achieved in that unnecessary visual interference effects
are avoided when printing the pattern.

25   Certainly, said markings which are included in the
symbols can be configured more or less arbitrarily.
However, it is preferred that the markings are of the
simplest possible configuration, for example round dots
as shown in the detailed description below.

30   The effect which is achieved with a coding-pattern-
ed product according to the above is that information can
be stored on the product in the form of, on the one hand,

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absolute-position information and, on the other hand, other information of a more or less arbitrary nature. The different coding patterns can be displaced in relation to one another by a more or less optional distance and be of

5   different spatial scales. The result is that the different patterns do not coincide with one another. It should be pointed out that a product according to the above can certainly be provided with a plurality of different coding patterns, for example three, in which the mutual dis-

10   placements between the patterns should certainly differ from one another. Such a patterned product has the advantage in comparison with the prior art according to the above that the information density is greater and, in practice, only limited by the nature of the surface of

15   the product and the printing technique which is used for the application.

Examples of other information which is stored in an information-coding pattern can be found in Applicant's Swedish Patent Application 0000947-2.

20   It is also advantageous that information is coded in different patterns since this entails simple distinguishing between different types of information such as distinguishing between position information and other information which can be descriptive of the product to which

25   the coding pattern is applied.

However, according to the prior art, each position is coded with a complex symbol which requires recognition of many different elements and which, therefore, is sensitive to interference. According to the invention, a

30   symbol is used instead, the value of which is specified by the location of a marking in relation to a raster point. There is thus one type of symbol for each value.

5

A device which will carry out reading, position determi-
nation and information decoding therefore only needs to
detect the occurrence of one marking and does not need to
be able to differentiate between different elements such
5   as the different lines in a bar code in order to deter-
mine the value of the symbols. The detection thus becomes
simpler and less sensitive to interference.

As mentioned, in the prior art, each position is coded
with a single symbol which, therefore, must be rather
10   complex. According to the invention, each position can
instead be coded with a plurality of symbols. Each
individual symbol can thus be made less complex and
simpler to detect with greater reliability. Furthermore,
in the prior art, each position is coded with a symbol
15   which is "isolated" from the symbols of surrounding posi-
tions. This limits the position resolution of the surface
occupied by the symbol for a position. The position-cod-
ing pattern according to the invention can be made up in
corresponding manner, each position being coded by an
20   "isolated" group of symbols. In a preferred embodiment
of the invention, however, each symbol contributes to
the coding of more than one position. In this manner,
a "floating" transition between different positions is
created. In other words, each position is coded partly
25   by the same symbols as the adjoining positions. The
floating coding is advantageous since it makes it pos-
sible to increase the position resolution. Furthermore,
it is possible to reduce the relationship between, on the
one hand, the number of symbols which a position-deter-
30   mining device must register in order to be able to carry
out a position determination reliably and, on the other
hand, the number of symbols which code a position.

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In a preferred embodiment, each symbol contributes to the coding of both a first and a second position coordinate. Thus, different symbols are not needed for the different coordinates, which makes the position code simpler and

5   the position resolution better. The coordinate system can be suitably Cartesian but other types of coordinate systems are also conceivable.

Furthermore, the value of each symbol can be advantageously translatable into at least one first digit

10   which is used for coding the first coordinate, and at least one second digit which is used for coding the second coordinate, the symbols in the position-coding pattern together representing a first position code for the first coordinate and a second position code for the

15   second coordinate. The two coordinates can then be coded independently of one another which makes the coding simpler when the coding is "floating". Preferably, the value of the symbol is represented in a binary manner, a first bit being used for the coding of a first coordinate

20   and a second bit for the coding of a second coordinate.

The position-coding pattern is advantageously based on a first cyclic, preferably binary, number series which has the characteristic that no sequence with a first predetermined number of digits appears more than once in the

25   number series. Due to the fact that the position-coding pattern is built up in this manner, it will contain inherent information about the positions so that the coordinates can be calculated according to predetermined rules. This is advantageous in that it means that the decoding

30   of the position-coding pattern can be implemented in an efficient manner in, for example, software. Besides, it will be much simpler to produce the position-coding pat-

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tern in this way compared with trying to randomly gene-
rate an unambiguous position-coding pattern of a floating
type.

In an advantageous embodiment, the product can comprise a
5   plurality of writing surfaces, each of which comprises
the position-coding pattern. For example, the product can
consist of a notepad with a plurality of sheets. The
position-coding patterns then differ for the different
writing surfaces by the sequence in the cyclic number
10   series with which a predetermined column or row begins.
The "same" pattern can thus be used for a plurality of
writing surfaces which can be separated from or
integrated with one another by allowing, for example, the
first column to begin in different positions in the num-
15   ber series.

Although the coding patterns have been discussed above in
terms of a separate position-coding pattern and a pattern
coding other information, it is possible that both coding
patterns encode position information. In such a case the
20   first position-coding pattern encodes positions from a
first region or area and the second position-coding
pattern encodes positions from a second region or area.
Needless to say, more than one position coding patterns
will also increase the total size of the region available
25   for use.

The coding patterns can be implemented with any parameter
whatever which can be used for producing symbols of the
above-mentioned type which can be detected by a detector.
The parameter can be electrical or chemical or of another
30   type. However, the pattern is preferably optically
readable which makes it simpler to apply to the surface.
The pattern should thus be able to reflect or absorb

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light but the light does not need to lie within the
visible range.

The raster and/or the raster points can be implemented on
the surface. In a preferred embodiment, however, the
5   raster and the raster points are virtual. Thus, the
raster is not marked on the surface at all but only
constitutes an imaginary raster which forms the base of
the coding but which can be located from the location
of the markings.

10   A second aspect of the invention is to produce by means
of a method a position- and an information-coding pattern
on a surface. The coding patterns comprise symbols, each
of which represents at least two different values, the
values depending on position information and other
15   information for the position- and the information-coding
pattern, respectively. The method includes determining a
first raster with raster points and a second raster with
raster points. The second raster is displaced in relation
to the first raster and has a different spatial scale
20   than the first raster. In a preferred embodiment,
furthermore, the configuration of the symbols in both
coding patterns is determined, each symbol in the
position-coding pattern comprising one raster point in
the first raster and at least one marking and each symbol
25   in the second coding pattern comprising one raster point
in the second raster and at least one marking, by dis-
placing, in dependence on the value of the respective
symbol, the location of the markings in relation to each
respective raster point in the first and, respectively,
30   second raster.

The method is suitable for implementation in the form of
a computer program which is implemented, with the skilled

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person's detailed knowledge in programming, for example
in a personal computer.

A method according to the above thus makes it possible
for information about absolute positions on the surface

5   of a product to be applied, together with any other
information in a second coding pattern which is displaced
and provided with a different spatial scale compared with
the position-coding pattern.

An advantage of the method is that the different coding

10   patterns do not necessarily have to be applied on the
surface of a product on the same occasion. Instead, the
times of applying the different patterns can be separated
and also be carried out by means of different application
devices. One example of such an advantageous situation is

15   to provide a sheet of paper with a background pattern in
the form of a position-coding pattern after which the
sheet of paper is used, for example, in a laser printer
coupled to a personal computer which prints an arbitrary
number of other position-coding patterns with mutually

20   varying displacements between their respective rasters.

One example of the utilization of a combined position-
and information-coding pattern can be in the form of
blank forms where a position-coding pattern is printed on
a sheet of paper. The sheet of paper is provided by a

25   user with an information-coding pattern and other graphi-
cal information such as, for example, a grid pattern,
figures etc. where information in the form of, for exam-
ple, sequences of digits which represent data which is
related to the grid pattern or the graphical figures is

30   coded with the aid of the symbols in the information-cod-
ing pattern. When the combined position- and information-
coding pattern is read, both position-information and the

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data which is related to the graphical figures which are
printed on the sheet of paper with the position-coding
pattern are obtained.

A third and a fourth aspect of the present invention

5   shows a method and a device, respectively, for reading a
position- and an information-coding pattern on a surface.
The coding patterns comprise symbols each of which repre-
sents at least two different values, the values depending
on position information and other information for the

10   position- and information-coding patterns, respectively.
The method includes reading a part of the surface and
storing the information read in the form of an image. A
first and a second virtual raster which contain raster
points are determined from the image, the rasters being

15   associated with the position- and information-coding pat-
terns, respectively. The rasters are displaced in rela-
tion to one another and have different spatial scales. A
plurality of symbols is located in both the position- and
the information-coding patterns. After that, the value of

20   each of the symbols is determined, each symbol in the
position-coding pattern comprising one raster point in
the first raster and at least one marking and each symbol
in the second coding pattern comprises one raster point
in the second raster and at least one marking, by deter-

25   mining, in a preferred embodiment, a displacement of the
location of the markings with respect to each respective
raster point in the first and the second raster, respec-
tively. The position-coding pattern in the image is sepa-
rated into a first position code for a first coordinate

30   for the partial surface and a second position code for a
second coordinate for the partial surface by translating
the value of each symbol into at least one first digit
for the first position code and at least one second digit

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for the second position code. The first coordinate is calculated by means of the first position code and the second coordinate is calculated by means of the second position code.

5   In the case both coding patterns encode position information, the first position-coding pattern encodes positions from a first region or area and the second position-coding pattern encodes positions from a second region or area. When reading symbols from a product

10   provided with such a combination of two position-coding patterns, coordinates will be simultaneously read from the two regions. This fact that coordinates from different regions have been encountered can be interpreted, e.g., as a particular event which may

15   trigger actions in the controlling software in the reading device or in a computer with which the device communicates. Moreover, the fact that coordinates from different regions are read simultaneously may be used to infer a more general association or link between the two

20   regions.

The method is advantageously implemented in the form of a computer program which is implemented with the skilled person's detailed knowledge in programming in, for example, a reading device in pen format which includes a

25   computer.

A central part of a reading method according to the above is to separate the different coding patterns into the input images of a partial surface. This is advantageously done by means of image-processing software in an input

30   device, or software in a computer connected to an input device. The image-processing software has the capacity to transfer image information from a spatial domain to a

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spatial frequency domain and to analyze the distribution
of the spatial frequencies in the input image. This
frequency distribution provides information about
distances between frequency peaks in the frequency domain

5   and thus also information about each spatial resolution
level, i.e. what different patterns and phase diffe-
rences, i.e. rotations between patterns, are found in
the image. The information obtained is then used for
determining coordinates of each of the, preferably vir-

10   tual, raster points in the patterns and thus makes it
possible to determine the displacement of each marking in
relation to the raster point in the symbols which make up
the pattern.

Further objectives, features and advantages of the

15   invention will become apparent from the following
detailed description of embodiments of the invention with
reference to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 schematically shows an embodiment of a product
which is provided with a position-coding pattern.

20   Figs 2a-2d schematically show how the symbols can be
configured in an embodiment of the invention.

Fig. 3 schematically shows an example of 4x4 symbols
which are used for coding a position.

Fig. 4 schematically shows a device according to the

25   present invention.

Fig. 5 schematically shows a position-coding pattern and
an information-coding pattern.

Fig. 6 schematically shows a power spectrum for spatial
frequencies of an image with two coding patterns.

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DESCRIPTION OF PREFERRED EMBODIMENTS

For the sake of clarity, the detailed description of the invention below has been divided into a number of part-descriptions. By way of introduction, a position-coding pattern will be presented separately with reference to

5   Figs 1, 2a-d and 3, without being combined with another coding pattern. The purpose of this is to clarify and exemplify the principle of coding information in the form of patterns consisting of symbols. After the presentation of the position-coding pattern, a device is then

10 presented in connection with Fig. 4, which is intended to read the pattern. After that, with reference to Fig. 5, it is shown how a combined position- and information-coding pattern can be arranged. Fig. 6 then illustrates a distribution of spatial frequencies for an input image of

15 a partial surface on which two coding patterns have been applied. In connection with Fig. 6, it will also be discussed how reading and interpreting of a coding-patterned surface is carried out according to the invention.

20 Fig. 1 shows a part of a product in the form of a sheet of paper 1 which, on its surface 2, is provided with an optically readable position-coding pattern 3 which enables position determination to be performed.
The position-coding pattern consists of symbols 4 which

25 are systematically arranged over the surface 2 so that it has a "patterned" appearance. The symbols comprise mark-ings which, for the sake of clarity, are round and with constant size in Fig. 1.

The sheet of paper has an x coordinate axis and a y

30 coordinate axis. In this case, position determination can be carried out on the surface of the whole product. In

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other cases, the surface provided with a position coding
pattern may consist of a smaller part of the product.

The position-coding pattern comprises a virtual raster
which thus is neither visible to the human eye nor can be
5   detected directly by a device which is to determine
positions on the surface, and a plurality of symbols 4
each being able to assume one of four values "1"-"4" as
will be described in the text that follows. In this con-
text, it should be pointed out that the position-coding
10   pattern in Fig. 1 has been greatly enlarged for the sake
of clarity. It is also shown only a part of the paper.

The position-coding pattern is arranged in such a manner
that the position of a partial surface on the writing
surface is coded by the symbols on this partial surface.
15   A first and a second partial surface 5a, 5b are shown by
dashed lines in Fig. 1. The part of the position-coding
pattern (in this case 4 x 4 symbols) which is located on
the first partial surface 5a codes a first position, and
the part of the position-coding pattern which is located
20   on the second partial surface 5b codes a second position.
The position-coding pattern is thus partially common to
the adjoining first and second positions. Such a
position-coding pattern is designated as "floating" in
this application.

25   Figs 2a-d show an embodiment of a symbol which can be
used in the position-coding pattern according to the
invention. The symbol comprises a virtual raster point
6 which is represented by the intersection between the
raster lines, and a marking 7 which has the form of a
30   dot. The value of the symbol depends on where the marking
is located. In the example in Fig. 2, there are four pos-
sible locations, one on each of the raster lines extend-

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ing from the raster points. The displacement from the
raster point is equal for all values. In the text which
follows, the symbol has the value 1 in Fig. 2a, the value
2 in Fig. 2b, the value 3 in Fig. 2c and the value 4 in

5   Fig. 2d. In other words, there are four different types
of symbol.

Each symbol can thus represent four values "1-4". This
means that the position-coding pattern can be divided
into a first position code for the x coordinate, and

10   a second position code for the y coordinate. The dividing
is done in accordance with the following:

Symbol value	x code	y code
1	1	1
2	0	1
3	1	0
4	0	0

Thus, the value of each symbol is translated in a first

15   digit, in this case bit, for the x code and a second
digit, in this case bit, for the y code. In this manner,
two completely independent bit patterns are obtained. The
patterns can be combined into a common pattern which is
coded graphically with the aid of a plurality of symbols

20   according to Fig. 2.

Each position is coded by means of a plurality of
symbols. In this example, 4x4 symbols are used for coding
a position in two dimensions, i.e. an x coordinate and a
y coordinate.

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The position code is built up by means of a number series of ones and zeros which have the characteristic that no sequence of four bits occurs more than once in the series. The number series is cyclic, which means that the

5   characteristic also applies if the end of the series is coupled together with its beginning. Thus, a sequence of four bits always has an unambiguously determined position in the number series.

The series can be maximally 16 bits long if it is to have

10 the characteristic for sequences of four bits described above. In this example, however, only a seven-bit-long series according to the following is used:

"0 0 0 1 0 1 0"

This series contains seven unique sequences of four bits

15 which code a position in the series according to the following:

Position in this series	Sequence
0	0001
1	0010
2	0101
3	1010
4	0100
5	1000
6	0000

For coding the x coordinate, the number series is written

20 sequentially in columns over the entire surface that is to be coded. The coding is based on the difference or

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position displacement between numbers in adjoining
columns. The magnitude of the difference is determined by
the position in the number series at which the column is
allowed to begin (i.e. with which sequence). More

5   specifically, taking the difference modulo seven between,
on the one hand, a number which is coded by a four-bit
sequence in a first column and which thus can have the
value (position) 0-6, and, on the other hand,
a corresponding number (i.e. a sequence on the same

10 "level") in an adjoining column, the result will be the
same independently of where along the two columns the
comparison is made. Using the difference between two
columns, an x coordinate can thus be coded which is con-
stant for all y coordinates.

15 Since each position on the surface is coded with
4x4 symbols in this example, three differences (having
the value 0-6) are available according to the above for
coding the x coordinate. The coding is then carried out
in such a manner that of the three differences, one will

20 always have the value 1 or 2 and the other two will have
the value in the interval 3-6. Thus, no differences will
be zero in the x code. In other words, the x code is con-
structed in such a manner that the differences will be as
follows:

25 (3-6) (3-6) (1-2) (3-6) (3-6) (1-2) (3-6) (3-6) (1-2) ...

Each x coordinate is thus coded with two numbers between
3 and 6 and a subsequent number which is 1 or 2. If three
is subtracted from the high numbers and one from the low
one, a number in mixed base will be obtained which

30 directly provides a position in the x direction, from
which the x coordinate can then be determined directly as
shown in the example below.

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Using the principle described above, it is thus possible
to code x coordinates 0,1,2... by means of numbers which
represent three differences. These differences are coded
with a bit pattern which is based on the above number

5   series. Finally, the bit pattern can be coded graphically
with the aid of the symbols in Fig. 2.

In many cases, when reading 4x4 symbols it will not be
possible to get a complete number which codes the x
coordinate but parts of two numbers. Since the least sig-

10   nificant part of the numbers is always 1 or 2, however, a
complete number can be reconstructed in a simple manner.

The y coordinates are coded in accordance with the same
principle as used for the x coordinates. The cyclic
number series is written repeatedly in horizontal rows

15   over the surface which is to be position-coded. Exactly
as in the case of the x coordinates, the rows are allowed
to begin at different positions, i.e. with different
sequences, in the number series. However, it is not dif-
ferences which are used for the y coordinates, but the

20   coordinates are coded with numbers which are based on the
starting position of the number series in each row. When
the x coordinate for 4x4 symbols has been determined, it
is, in fact, possible to determine the starting position
in the number series for the rows which are included in

25   the y code in the 4x4 symbols. In the y code, the most
significant digit is determined by allowing this to be
the only one that has a value in a specific interval. In
this example, one row of four is allowed to begin at
position 0-1 in the number series to indicate that this

30   row relates to the least significant digit in a y coor-
dinate, and the other three begin at positions 2-6. In

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the y direction, there is thus a series of numbers as
follows:

(2-6) (2-6) (2-6) (0-1) (2-6) (2-6) (2-6) (0-1) (2-6) ...

Each y coordinate is thus coded with three numbers

5   between 2 and 6 and a subsequent number between 0 and 1.

If 0 is subtracted from the low number and 2 from the
high ones, a position in the y direction in mixed base is
obtained, in the same manner as for the x direction, from
which the y coordinate can be determined directly.

10 With the above method, it is possible to code
4 x 4 x 2 = 32 positions in the x direction. Each such
position corresponds to three differences, giving
3 x 32 = 96 positions. Furthermore, it is possible to
code 5 x 5 x 5 x 2 = 250 positions in the y direction.

15 Each such position corresponds to 4 rows, giving
4 x 250 = 1000 positions. Together, it is thus possible
to code 96000 positions. Since the x coding is based on
differences it is, however, possible to select the posi-
tion at which the first number series begins. Taking

20 into consideration that this first number series can
begin at seven different positions, it is possible to
code 7 x 96000 = 672000 positions. The starting position
of the first number series in the first column can be
calculated when the x coordinate has been determined. The

25 above-mentioned seven different starting positions of the
first series can code different sheets or writing sur-
faces on a product.

To further illustrate the invention according to this
embodiment, a specific example follows here which is

30 based on the embodiment of the position code described.

20

Fig. 3 shows an example of an image with 4x4 symbols
which are read by a device for position determination.

These 4x4 symbols have the following values:

4 4 4 2

5   3 2 3 4

4 4 2 4

1 3 2 4

These values represent the following binary x and y
codes:

10

        x code: y code:

        0 0 0 0   0 0 0 1

        1 0 1 0   0 1 0 0

        0 0 0 0   0 0 1 0

        1 1 0 0   1 0 1 0

The vertical x sequences code the following positions in
the number series: 2 0 4 6. The differences between the
columns will be -2 4 2, which modulo 7 gives 5 4 2,
15   which, in mixed base codes position (5-3) x 8 + (4-
3) x 2 + (2-1) = 16 + 2 + 1 = 19. Since the first coded x
position is position 0, the difference which lies in the
interval 1-2 and which appears in the 4x4 symbols is the
twentieth such difference. Since, furthermore, there are
20   a total of three columns for each such difference and
there is a start column, the farthest vertical sequence
to the right in the 4x4 x code belongs to the 61st column
in the x code (3 x 20 + 1 = 61) and that farthest to the
left belongs to the 58th.

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The horizontal y sequences code the positions 0 4 1 3 in
the number series. Since these series begin in the 58th
column, the starting position of the rows are these
numbers minus 57 modulo 7, providing the starting

5   positions 6 3 0 2. Translated into digits in the mixed
base, this becomes 6-2, 3-2, 0-0, 2-2 = 4 1 0 0, where
the third digit is the least significant digit in the
number in question. The fourth digit is then the most
significant digit in the next number. In this case, it

10   must be the same as in the number in question. (The
exception is when the number is question consists of
the highest possible digits in all positions. It is then
apparent that the beginning of the next number is one
greater than the beginning of the number in question).

15   The position of the four-digit number becomes 0x50 + 4x10
+ 1x2 + 0x1 = 42 in the mixed base.

The third row in the y code is thus the 43rd which has
starting position 0 or 1, and since there are four
rows in total in each such row, the third row is number

20   43x4=172.

Thus, in this example, the position of the top left-hand
corner for the 4x4 symbol group is (58,170).

Since the x sequences in the 4x4 group begin in row 170,
the x columns of the entire pattern begin at positions

25   ((2 0 4 6) -169) modulo 7 = 1 6 3 5 of the number series.
Between the last starting position (5) and the first
starting position, the numbers 0-19 are coded in mixed
base and by adding together the representations for
numbers 0-19 in mixed base, the total difference between

30   these columns is obtained. A primitive algorithm for
doing this is to generate these twenty numbers and
directly add together their digits. The sum obtained is

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called s. The sheet of paper or writing surface is then
given by (5-s) modulo 7.

In the example above, an embodiment has been described in
which each position is coded with 4 x 4 symbols and a

5   number series with 7 bits is used. Naturally, this is
only an example. Positions can be coded with more or
fewer symbols. The number of symbols does not need to be
the same in both directions. The number series can have
different lengths and do not need to be binary but may be

10 built on another base. Different number series can be
used for coding in the x direction and coding in the
y direction. The symbols can have different numbers of
values.

In the example above, furthermore, the marking is a dot.

15 Naturally, it can have a different appearance. For
example, it may consist of a polygon.

In the example above, the symbols are used within
a square partial surface for coding a position. The par-
tial surface can have another form, for example hexago-

20 nal. Neither do the symbols need to be arranged in rows
and columns at an angle of 90 degrees with respect to one
another but can also be arranged in other configurations.

For the position code to be detectable, the virtual
raster must be determined. In the case of only one pat-

25 tern, this can be done by studying the distance between
different markings. The shortest distance found between
two markings must originate from two adjoining symbols
having the value 1 and 3 so that the markings are located
on the same raster line between two raster points. When

30 such a pair of markings has been detected, the associated
raster points can be determined with knowledge of the
distance between the raster points and the displacement

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of the markings from the raster points. Once two raster
points have been located, further raster points can be
determined by means of measured distances to other mark-
ings and with knowledge of the relative distances of the
5   raster points. With two or more superimposed coding pat-
terns, the process of identifying the patterns is some-
what different, as will be described in greater detail
below in connection with Figs 5 and 6.

An embodiment of a device for position determination is
10   shown schematically in Fig. 4. It comprises a casing 11,
which has the approximate format of a pen. In a short end
of the casing, there is an opening 12. The short end is
intended to bear against or be held at a short distance
from the surface from which information is to be fetched.

15   The casing mainly accommodates an optical part, an
electronics part and a power supply.

The optical part comprises at least one light-emitting
diode 13 for illuminating the surface which is to be
imaged and a light-sensitive area sensor 14, for example
20   a CCD or CMOS sensor for registering a two-dimensional
image. The device may also contain a lens system.

The power supply for the device is obtained from a
battery 15 which is mounted in a separate compartment in
the casing.

25   The electronics part comprises an image-processing means
16 for determining a position on the basis of the image
registered by the sensor 14 and, more specifically, a
processor unit with a processor which is programmed for
reading images from the sensor and carrying out position
30   determination and information decoding on the basis of
these images.

24

In this embodiment, the device may also comprise a pen
point 17 by means of which it is possible to write normal
pigment-based writing on the surface on which the
position determination is to be carried out. The pen

5   point 17 can be retracted and extended so that the user
can control whether or not it is to be used. In certain
applications, the device does not need to have any pen
point at all.

The device also comprises buttons 18, by means of which

10   the device is actuated and controlled. It also has a
transceiver 19 for wireless transmission, e.g. by means
of IR light or radio waves, of information to and from
the device. The device can also comprise a display 20 for
showing positions or registered information.

15   Applicant's International Patent application WO 98/20446
describes a device for registering text. This device can
be used for position determination and information
reading/decoding if it is programmed in a suitable
manner. It if it to be used for pigment-based writing, it

20   must also have a pen point.

The device can be divided into different physical
casings, a first casing containing components which are
necessary for obtaining images of the coding pattern and
for transferring them to components which are located in

25   a second casing and which carry out the calculations on
the basis of the registered image or images.

As mentioned, calculations are carried out by a processor
which thus must have software for locating and decoding
the symbols in an image and for determining the positions

30   from the codes thus obtained. On the basis of the above
example, an expert can design software which carries out

25

position determination on the basis of an image of a part
of a position-coding pattern.

In the above embodiment, the pattern is optically
readable and the sensor is thus optical. As mentioned,

5   the pattern can be based on a parameter other than an
optical parameter. In such a case, naturally, the sensor
must be of the type which can read the parameter in ques-
tion.

In the above embodiment, the raster is a grid network. It

10   can also have other forms.

In the embodiment above, it is not the longest possible
cyclic number series which is used. This provides
a certain redundancy which can be used, for example, for
checking the rotation of the group of symbols read.

15   Fig. 5 shows a position-coding pattern combined with an
information-coding pattern. The position-coding pattern
in Fig. 5 comprises a number of symbols of which markings
502 are shown together with a first raster comprising a
number of raster lines 501. The information-coding

20   pattern in Fig. 5 also comprises a number of symbols, of
which markings 504 are shown together with a second
raster comprising a number of raster lines 503. Both
patterns are thus of the same type as the position-coding
pattern described in detail above, which is why

25   no detailed description will be given with respect to how
information is coded by means of the location of the
markings with respect to each respective raster. Note,
however, that the markings 502,504 are not located along
the raster lines as in the example described above.

30   Rather, the markings 502,504 are located in the
respective quadrant defined by the intersections of the
raster lines.

26

As has been discussed above, both coding patterns may in
fact encode position information. In such a case the
first position-coding pattern encodes positions from a
first region or area and the second position-coding

5   pattern encodes positions from a second region or area,
thus increasing the total size of the region available
for use.

As mentioned above, the raster lines 501, 503 can
advantageously be virtual ones, i.e. invisible on the

10   product on which the pattern is applied. The raster lines
in Fig. 5 are thus shown only to increase clarity.

The rasters with raster lines 502, 504 have a first
spatial scale 505 and a second spatial scale 506 respec-
tively and are displaced with respect to one another by

15   a displacement distance 507. The patterns in Fig. 5, like
the above illustrations, have certainly been exaggerated
in scale to increase clarity in these illustrations.

The different coding patterns can be displaced in
relation to one another by a more or less optional dis-

20   tance and can be of different spatial scales. The result
is that the different patterns do not coincide with one
another. It is preferred that the displacement between
the first and the second raster, the distance between
the raster points in the first raster and the distance

25   between the raster points in the second raster are
related such that interference effects are avoided. For
example, the distances may not have a common integer
denominator which is greater than one. It should also be
pointed out that a product can certainly be provided with

30   a plurality of different coding patterns, for example
three, in which the mutual displacements between the
patterns differ from one another. Such a patterned

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product can also be provided with patterns with an
information density which is only limited by the nature
of the surface of the product and the printing technique
used for the application.

5   The coding patterns may of course be applied to the
product at different instances in time. For example, a
product may be provided for sale having only a first
position-coding pattern applied on it's surface. A user
of the product may subsequently apply, i.e. print, a
10   second coding pattern on the product, and thereby
providing the product with further encoded information.
Products, e.g. sheets of paper, may be provided being
completely covered by a first coding pattern with a very
high resolution. A user subsequently applies, by using a
15   more or less conventional laser printer, a second coding
pattern on at least a part of the area already provided
with the first coding pattern. This second coding pattern
may have a lower resolution as compared with the first
pattern, being dependent on the capability of the
20   specific printer used, although the pattern may encode
user specific information.

Although it has been described above that the two, or
more, coding patterns are similar in all but scale, the
two coding patterns may differ in other respects. For
25   example, one of the coding patterns may comprise markings
of different sizes where the variation in size holds the
information of the pattern. It is possible to use any
combination of coding patterns known in the art within
the scope of the present invention.

30   A method for reading and interpreting a patterned surface
according to Fig. 5 will now be described with reference
to Fig. 6. The method is advantageously implemented in an

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input device such as the device described in connection
with Fig. 4.

In a first step, a patterned surface is read, an image of
the pattern being stored in an image memory. The image

5   thus only comprises a dot pattern without the raster
lines which are indicated in Fig. 5. In this image, the
center is then determined in some sense, for example in
the form of peak blackening or the like, for each dot and
is described as a spike-shaped maximum at this point.

10 An analytic two-dimensional Fourier transformation is
then carried out on the data set which consists of a
number of spike-shaped maxima. This operation provides a
two-dimensional spectrum of spatial frequencies. Fig. 6
illustrates such a spectrum along a spatial frequency

15 axis S where two peaks 601, 602 for two spatial fre-
quencies S1, S2 are shown. A power axis P is shown but
without any marked scale since the figure is only intend-
ed to illustrate the spectrum in qualitative terms. The
peaks originate from the typical spatial distance between

20 markings 502 in the position-coding pattern and, respec-
tively, the typical spatial distance between markings 504
in the information-coding pattern. From a two-dimensional
image of a spatial spectrum (not illustrated), it should
be possible to read off the phase differences between the

25 peaks, these phase differences representing the rotation
of the patterns.

These values, i.e. the typical spatial distance and
rotations show the nature of the two patterns in terms of
around which coordinates the actual dots are displaced.

30 After that, the calculation of positions and decoding of
other information from the two patterns are carried out
as described above.

29

CLAIMS

1. A product which has a surface which is provided with a
first coding pattern and a second coding pattern
comprising symbols each of which represents at least two
5   different values, in which
       - each symbol in the first coding pattern comprises
one raster point and at least one marking, the raster
point being included in a first raster which extends over
the surface,
10   - each symbol in the second coding pattern comprises
one raster point and at least one marking, the raster
point being included in a second raster which is
displaced in relation to the first raster and has a dif-
ferent spatial scale than the first raster.

15 2. A product according to claim 1, in which the value of
each symbol in the first and the second pattern is
indicated by the location of said marking in relation
to a raster point in the first and, respectively, second
raster.

20 3. A product according to claim 2, in which the dis-
placement between the first and the second raster, the
distance between the raster points in the first raster
and the distance between the raster points in the second
raster is such that interference effects are avoided.

25 4. A product according to any one of claims 1-3, in which
essentially all markings in each coding pattern are
identical.

5. A product according to any one of claims 1-4, in which
the first coding pattern is a position-coding pattern
30 which codes a plurality of positions on the surface, each
position being coded by a plurality of symbols and the

30

second coding pattern being an information-coding pattern
which codes other information.

6. A product according to claim 5, in which each symbol
in the first coding pattern contributes to the coding of

5   more than one of said plurality of positions.

7. A product according to claim 5 or 6, in which each
symbol in the first coding pattern contributes to the
coding of both a first and a second position coordinate.

8. A product according to claim 7, in which the value of

10   each symbol in the first coding pattern can be translated
into at least one first digit which is used for coding
the first position coordinate and at least one second
digit which is used for coding the second position
coordinate, the symbols in the first coding pattern toge-

15   ther representing a first position code for the first
position coordinate and a second position code for the
second position coordinate.

9. A product according to any one of claims 5-8, in which
the first coding pattern is based on a first cyclic

20   number series which has the characteristic that
no sequence with a first predetermined number of digits
occurs more than once in the number series.

10. A product according to claim 6, in which the first
coordinate is coded in that a first cyclic number series,

25   which has the characteristic that no sequence with a
first predetermined number of digits occurs more than
once in the number series, is repeated in columns over
the surface, the columns beginning at different places in
the number series.

30   11. A product according to claim 10, in which the second
coordinate is coded with a second cyclic number series

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which has the characteristic that no sequence with a
second predetermined number of digits occurs more than
once in the number series, being repeated in rows over
the surface, the rows beginning at different places in
5   the number series.

12. A product according to claim 11, in which the product
comprises a plurality of writing surfaces each of which
comprises the first coding pattern, the first coding
pattern of each respective writing surface differing for
10   the different writing surfaces through the sequence in
the cyclic number series with which a predetermined
column or row begins.

13. A product according to any one of the preceding
claims, in which the second coding pattern is a position
15   coding pattern similar to the first coding pattern.

14. A product according to any one of the preceding
claims, in which said raster and said raster points are
virtual ones.

15. A product according to any one of the preceding
20   claims, in which each symbol in the first and the second
coding pattern have exactly one marking which can be
placed in one of four predetermined positions on the
lines of each respective raster, so that the symbol has
exactly four values.

25   16. A product according to one of the preceding claims,
in which the coding patterns are optically readable.

17. A method for producing a position- and information-
coding pattern on a surface, in which the coding patterns
comprise symbols each of which represents at least two
30   different values, the values depending on position
information and other information for the position- and

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the information-coding pattern, respectively, comprising:

- determining a first raster with raster points and a second raster with raster points, the second raster being displaced in relation to the first raster and
5 having a different spatial scale than the first raster,

- determining the configuration of the symbols in both coding patterns, each symbol in the position-coding pattern comprising one raster point in the first raster and at least one marking and in which each symbol in the
10 second coding pattern comprising one raster point in the second raster of at least one marking.

18. A method according to claim 17, in which determining the configuration of the symbols comprises displacing the location of the markings in relation to each respective
15 raster point in the first and, respectively, second raster in dependence on the value of a respective symbol.

19. A method according to claim 18, in which determining the raster comprises that the displacement between the first and the second raster, the distance between
20 the raster points in the first raster and the distance between the raster points in the second raster is such that interference effects are avoided.

20. A method according to any one of claims 17-19, in which the position-coding pattern codes a plurality of
25 positions on the surface and each position is coded by a plurality of symbols.

21. A method according to claim 20, in which each symbol in the first coding pattern contributes to the coding of more than one of said plurality of positions.

30 22. A method according to claim 20 or 21, in which each symbol in the position-coding pattern contributes to the coding of both a first and a second position coordinate.

23. A method according to claim 22, in which the value of
each symbol in the position-coding pattern can be
translated into at least one first digit which is used
for coding the first position coordinate and at least one
5   second digit which is used for coding the second position
coordinate, the symbols in the position-coding pattern
together representing a first position code for the first
position coordinate and a second position code for the
second position coordinate.

10   24. A method according to any one of claims 20-23, in
which the position-coding pattern is based on a first
cyclic number series which has the characteristic that no
sequence with a first predetermined number of digits
occurs more than once in the number series.

15   25. A method according to claim 21, in which the first
coordinate is coded in that a first cyclic number series,
which has the characteristic that no sequence with a
first predetermined number of digits occurs more than
once in the number series, is repeated in columns over
20   the surface, the columns beginning at different places in
the number series.

26. A method according to claim 25, in which the second
coordinate is coded in that a second cyclic number
series, which has the characteristic that no sequence
25   with a second predetermined number of digits occurs more
than once in the number series, is repeated in rows over
the surface, the rows beginning at different places in
the number series.

27. A method according to claim 26, comprising
30   determining a coding pattern for a plurality of writing
surfaces each of which comprises the position-coding pat-
tern, the position-coding pattern of each respective

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writing surface differing for the different writing sur-
faces through the sequence in the cyclic number series
with which a predetermined column or row begins.

28. A method according to any one of claims 17-27, in
5   which the production of the information coding pattern
entails producing a second position coding pattern having
symbols that represent positions.

29. A method according to any one of claims 17-28, in
which said raster and said raster points are virtual
10 ones.

30. A method according to any one of claims 17-29, in
which each symbol in the position- and the information-
coding pattern has exactly one marking which can be
placed in one of four predetermined positions on the
15 lines of each respective raster, so that the symbol has
exactly four values.

31. A method according to any one of claims 17-30, in
which the information coding pattern is produced
subsequent to the production of the position coding
20 pattern.

32. A computer program which comprises instructions for
causing a computer to execute a method according to any
one of claims 17-31.

33. A method for reading a position- and an information-
25 coding pattern on a surface, in which the coding patterns
comprise symbols each of which represents at least two
different values, the values depending on position
information and other information for the position- and
information-coding patterns, respectively, comprising
30   - reading a part of the surface and storing the read
information in an image,

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- determining a first virtual raster with raster points in the image associated with the position-coding pattern and a second virtual raster with raster points in the image associated with the information-coding pattern,

5   the second raster being displaced in relation to the first raster and having another spatial scale than the first raster,

- locating a plurality of symbols in the position- and information-coding patterns,

10   - determining the value of each of said predetermined plurality of symbols, each symbol in the position-coding pattern comprising one raster point in the first raster and at least one marking and each symbol in the second coding pattern comprising one raster point in the

15   second raster and at least one marking,

- separating the position-coding pattern in the image into a first position code for a first coordinate for the partial surface and a second position code for a second coordinate for the partial surface by translating

20   the value of each symbol into at least one first digit for the first position code and at least one second digit for the second position code, and

- calculating the first coordinate by means of the first position code and the second coordinate by means

25   of the second position code.

34. A method according to claim 33, in which the determining of the value of each of said predetermined plurality of symbols comprises determining a displacement of the location of the markings in relation to a

30   respective raster point in the first and, respectively, second raster.

36

35. A method according to any one of claims 33 to 34, in which the symbols of the information coding pattern represent positions and where the method comprises determining symbol values, separation into position codes

5   and calculation of coordinates in a similar manner as for the position coding pattern.

36. A computer program which comprises instructions for causing a computer to execute a method according to any one of claims 33-35.

10 37. A device for reading a position- and an information-coding pattern on a surface, in which the coding patterns comprise symbols each of which represents at least two different values, the values depending on position information and other information for the position- and,

15 respectively, information-coding pattern, comprising means for

- reading a part of the surface and storing the information read in an image,

- determining a first virtual raster with raster

20 points in the image associated with the position-coding pattern and a second virtual raster with raster points in the image associated with the information-coding pattern, the second raster being displaced in relation to the first raster and having another spatial scale than the

25 first raster,

- locating a plurality of symbols in the position- and information-coding patterns,

- determining the value of each of said predeter- mined plurality of symbols, each symbol in the position-

30 coding pattern comprising one raster point in the first raster and at least one marking and each symbol in the second coding pattern comprising one raster point in the

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second raster and at least one marking,

  - separating the position-coding pattern in the image into a first position code for a first coordinate for the partial surface and a second position code for a

5 second coordinate for the partial surface by translating the value of each symbol into at least one first digit for the first position code and at least a second digit for the second position code, and

  - calculating the first coordinate by means of the

10 first position code and the second coordinate by means of the second position code.

38. A device according to claim 37, in which the means for determining the value of each of said predetermined plurality of symbols comprise means for determining a

15 displacement of the location of the markings in relation to each respective raster point in the first and, respectively, second raster.

39. A device according to any one of claims 37 to 38, in which the symbols of the information coding pattern

20 represent positions, comprising means for determining symbol values, separation into position codes and calculation of coordinates.

40. A device according to any one of claims 37-39, in which the device is handheld.

25 41. A device according to any one of claims 37-40, in which the device has means for wireless transmission of information.
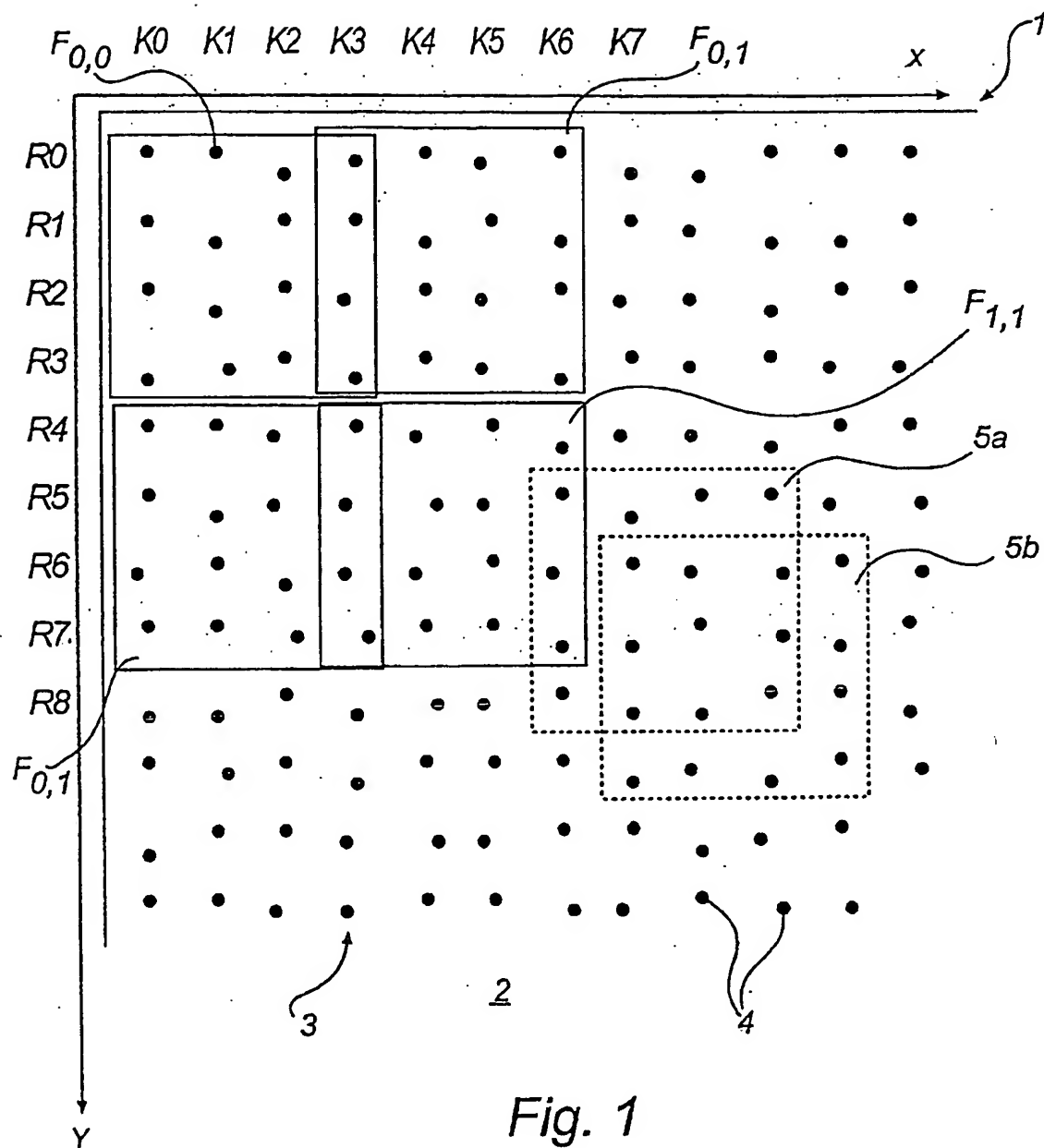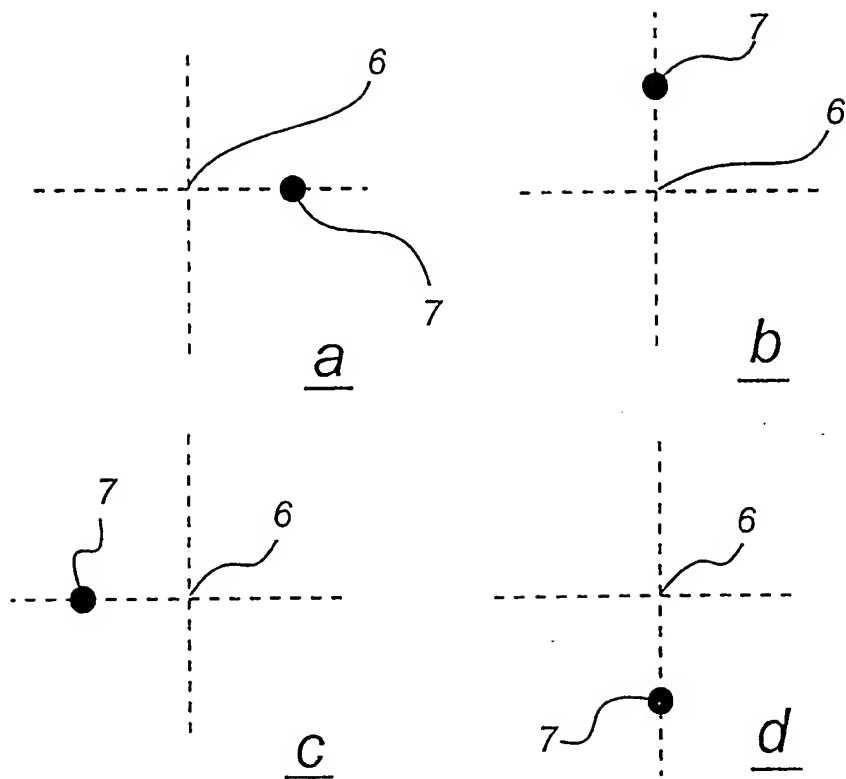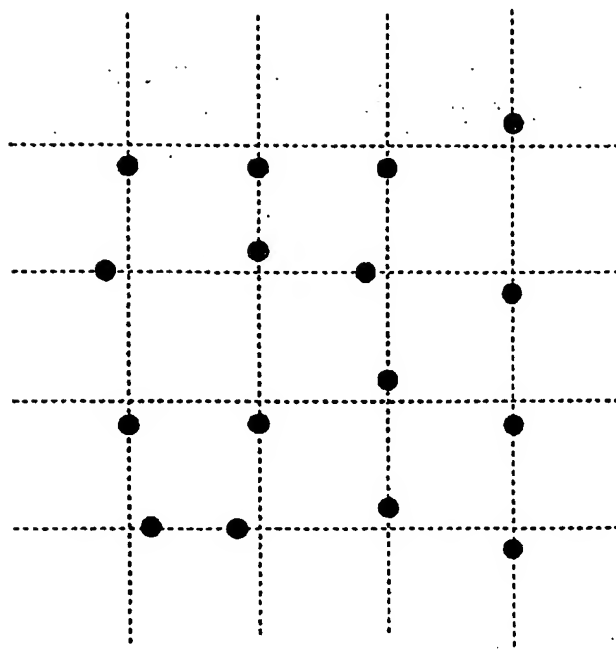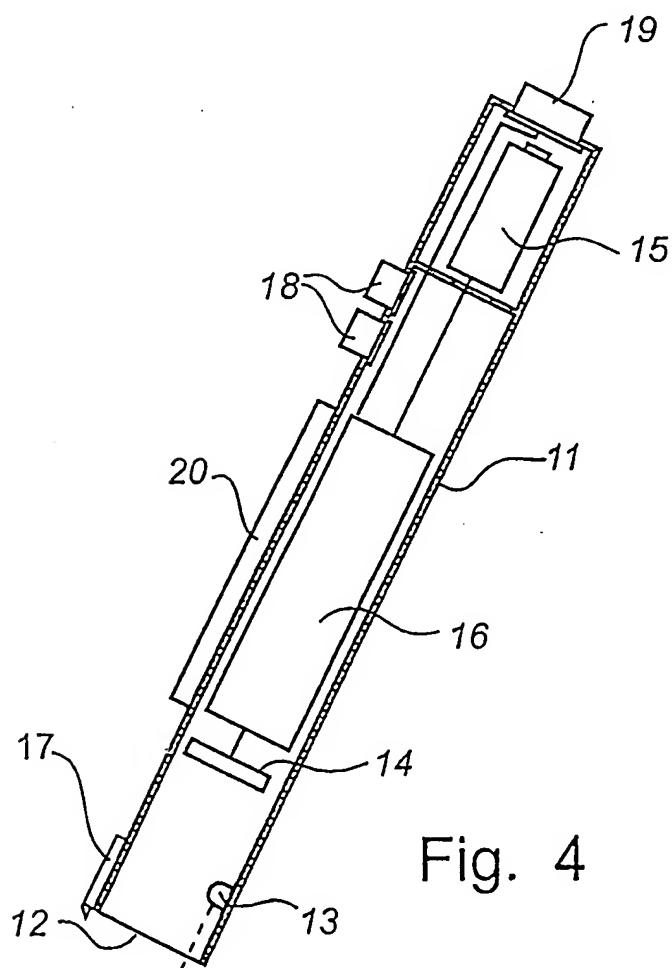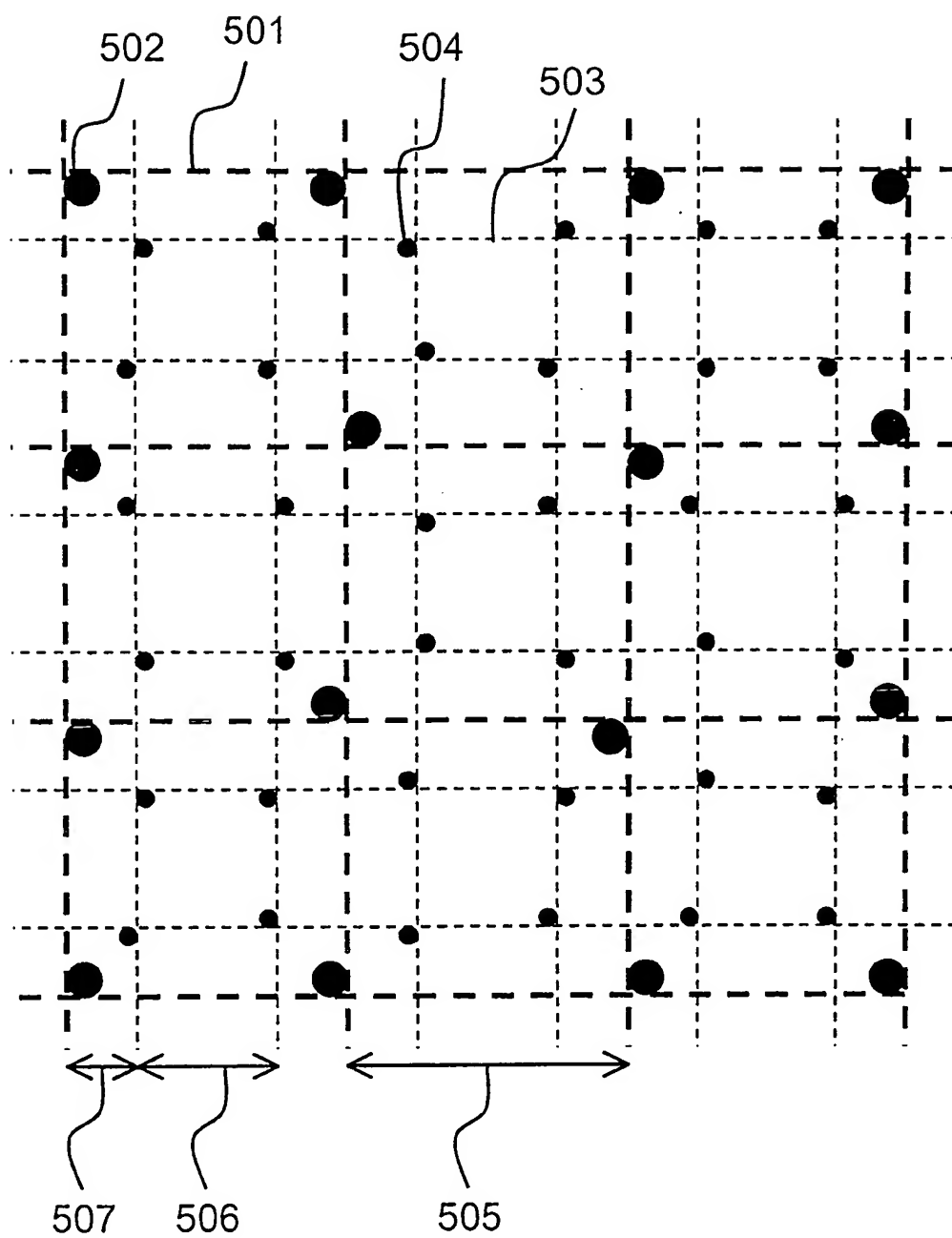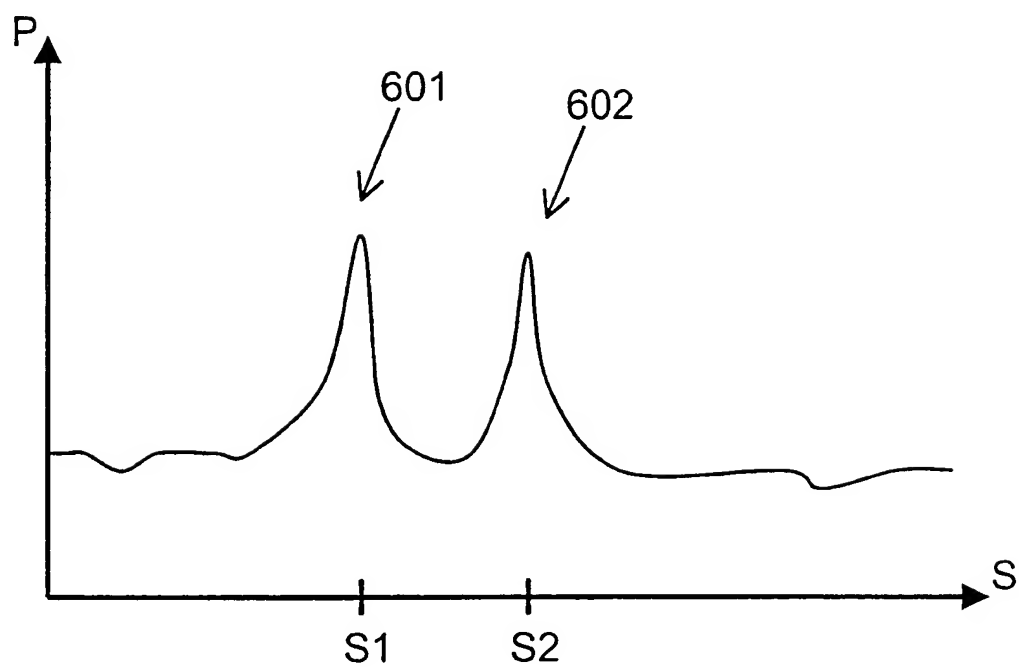
Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 01/00611

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G06K 1/12, G06K 19/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: G06F, G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI-DATA

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0887765 A2 (OLYMPUS OPTICAL LTD), 30 December 1998 (30.12.98), figure 1B, abstract --	1-40
A	EP 0764944 A2 (OLYMPUS OPTICAL CO., LTD.), 26 March 1997 (26.03.97), column 27, line 51 - column 28, line 7, claim 1, Figures 1A, 3A,4B,5A,6A,12,14 --	1-40
A	US 5221833 A (D. HECHT), 22 June 1993 (22.06.93), see the whole document --	1-40

☒	Further documents are listed in the continuation of Box C.	☒	See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance		
"E"	earlier application or patent but published on or after the international filing date	"X"	document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means		
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Date of the actual completion of the international search	Date of mailing of the international search report
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